



### TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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### Overview



- Energy Storage Goals & Mission
- DOD Power & Energy Requirements
- DOD Energy Storage R&D Challenges
- Vehicle Applications & Approach
- Army Ground Vehicle Energy Storage R&D Programs
  - Roadmap
  - Functional Breakdown/ Highlighted R&D Programs & Projects
- Summary



## Energy Storage Goals and Mission





#### **Energy Storage Goals**

- Develop safe, reliable and cost effective energy storage systems
- Reduce battery weight & volume burden (Increase Energy & Power Density)
- Reduce logistics and fuel burdens
- Enhance performance, extend calendar and cycle life

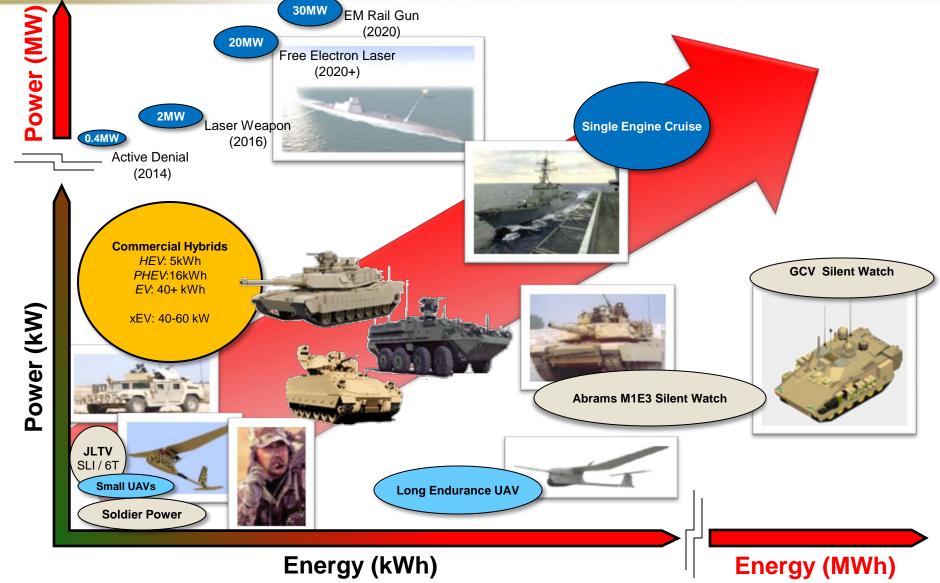
### **Energy Storage Mission**

- Develop and mature advanced ES technologies for transfer to vehicle platforms
- Test & evaluate ES technologies for prequalification and to assess
   TRL (Technology Readiness Level).
- Identify technology barriers and develop technical solutions
- Be recognized as the team of experts in ES components and systems
- Provide technical support to customers, other teams and government agencies for all ES requirements
- Provide cradle-to-grave support for all Army ES systems



# UNCLASSIFIED: Dist A. Approved for public release DOD Power & Energy Requirements





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# Energy Storage Technology Challenges



### **Energy Storage Challenges:**

- Cell & system safety & reliability
- Higher energy / higher power designs & chemistries
- Power vs. energy trade-off design optimization
- Manufacturing process development and cost control
- Thermal management
- System control and cell & battery management systems
- Alternative electrochemical improvements
- Thermal runaway process and its control
- Standardization of cells, modules and packs (logistics)

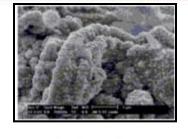


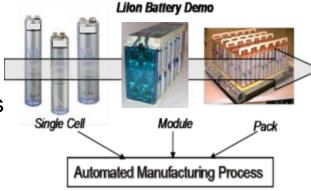


















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## Army Applications & Approach



### Army Applications/Drivers:

#### **TARDEC - Ground**

- Major Applications
  - > Robotics
  - Survivability
  - Weapons Systems
  - Electromagnetic Armor (EM Armor)
  - Starting, Lighting and Ignition (SLI)
  - Hybrid Vehicle Acceleration and Silent Mobility
  - Silent Watch
- Approach
  - Standard Form Factor (6T)
  - Ultra-capacitor/Battery/Fuel Cell Hybrid Power Sources



Hit Avoidance





**Targeting Systems** 



### Energy Storage Team Focuses on Batteries:

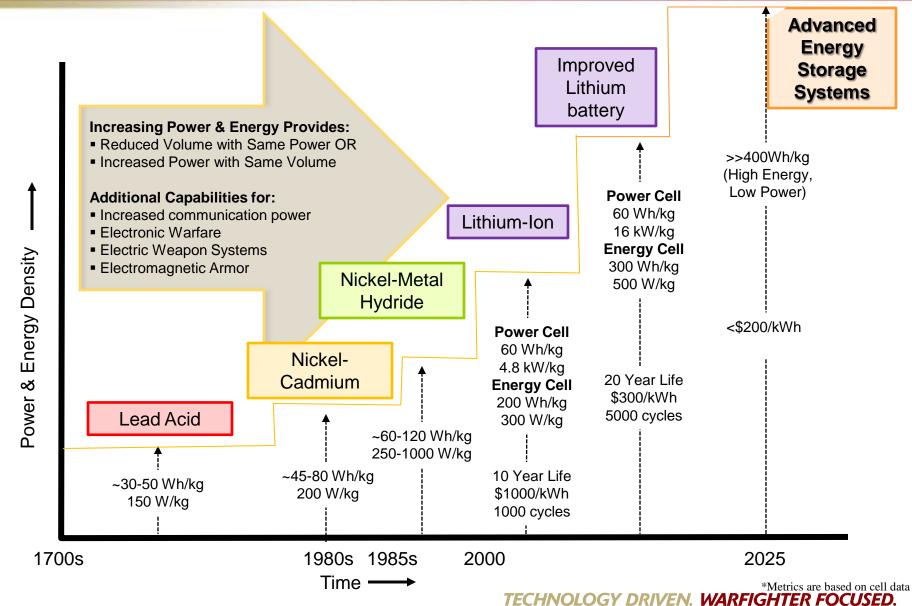
- True silent watch and silent mobility
- Serves as reservoir to store energy to meet power demands and manage platform power
- > Provide power source for advanced weapons.

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# Battery Robadmap Battery Power and Energy Versus Time

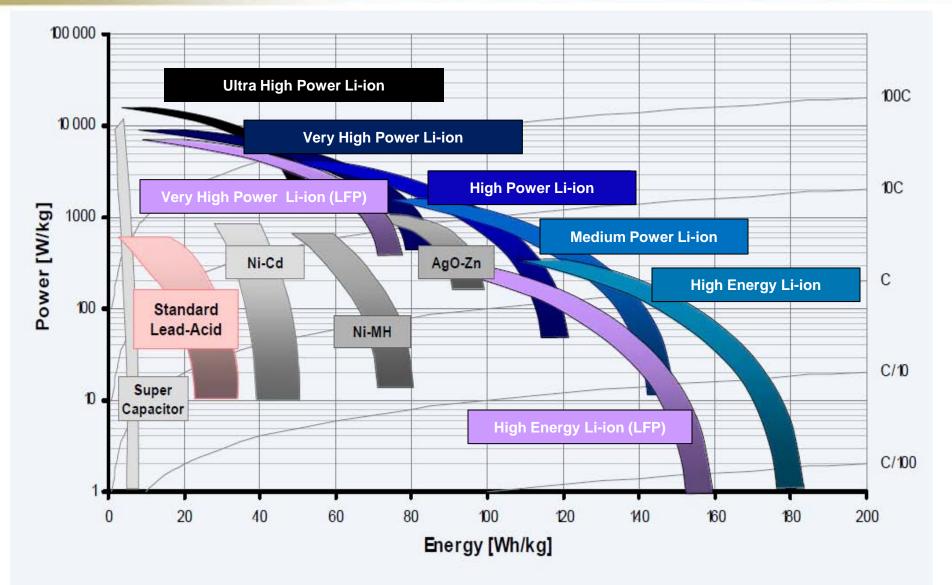






# Energy Storage Technology Trade-Offs & Capabilities







# UNCLASSIFIED: Dist A Approved for public release IARDEC Programs Functional Breakdown



### **Energy Storage Functional Breakdown**



### Basic Research

- Lithium plating phenomenon in Li-ion batteries
- Study on the mechanism of thermal runaway in VRLA Batteries and Methods of Suppression
- Study of electrode/current collector interface & safe separator for Li-ion batteries
- Development of high energy density anode materials for improved Li-ion batteries
- Alternative electrolyte for use in lithium-ion batteries (higher voltage, improved performance)

# Applied / Applications Research

- Electromagnetic Armor Power Maturation
- Nickel-Zinc 6T Battery Development
- Development of 6T battery for SLI and silent watch using Li-ion chemistries
- Absorbed Glass Matt lead acid battery for 24V military 4HN battery

### Manufacturing

- High Power, High Energy Density Li-Ion Battery Manufacturing Program
- Lithium-Ion Cell/Battery Pack Manufacturing
- Advanced battery material scale-up facility

# Battery Management / Safety

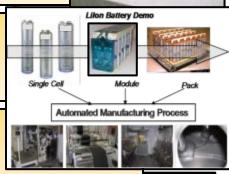
- In-House BMS evaluation for PM HBCT & new laboratory
- Universal BMS using novel algorithms for battery health
- Ballistic and abuse tolerance studies on cells, module and packs
- Development of advanced diagnostic tools for cycled cells

# Alternative Systems

- Hybrid Power Module
- Lithium-Titanate Hybrid Vehicle Pack Integration

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• Characterization of ultra-capacitors for SLI and high power applications







## Summary



- Army has a diversified energy storage portfolio supporting a wide-range of customers
- Army has and is actively seeking collaboration with other Government Agencies, and Commercial & Military OEM's
- Army has projects supporting several different functional areas in Energy Storage including: basic research, applied research & applications, manufacturing, battery management & safety, and alternative systems
- Army labs currently perform a wide variety of testing activities and has an established program for technology maturation and technology readiness level verification
- Army is actively involved in the development of battery standards and standard vehicle battery products



## Its all about the War Fighter!



# Thank you. Questions?



